USING AUDACITY^R AS A HOMEMADE LASER LIGHT SHOW CONTROLLER
By Nick Cinquino 1/8/09

The first laser light shows appeared in the late 1960's. At that time the equipment was obscenely expensive. Today, mid-powered laser diodes (100mW range) are affordable and relatively easy to power, and bright enough for home laser shows. Even the dirt-cheap red and green laser pointers can be used. The other items needed are also affordable and/or easy to build. By today's definition, a modern laser show involves scanning the laser beam in 2 dimensions (X and Y, or up/down and right/left) with moving mirrors, usually accompanied by music.

An excellent brief history of the laser light show can be found at the following site: http://www.laserfx.com/Backstage.LaserFX.com/Newsletter/BriefHistory.html

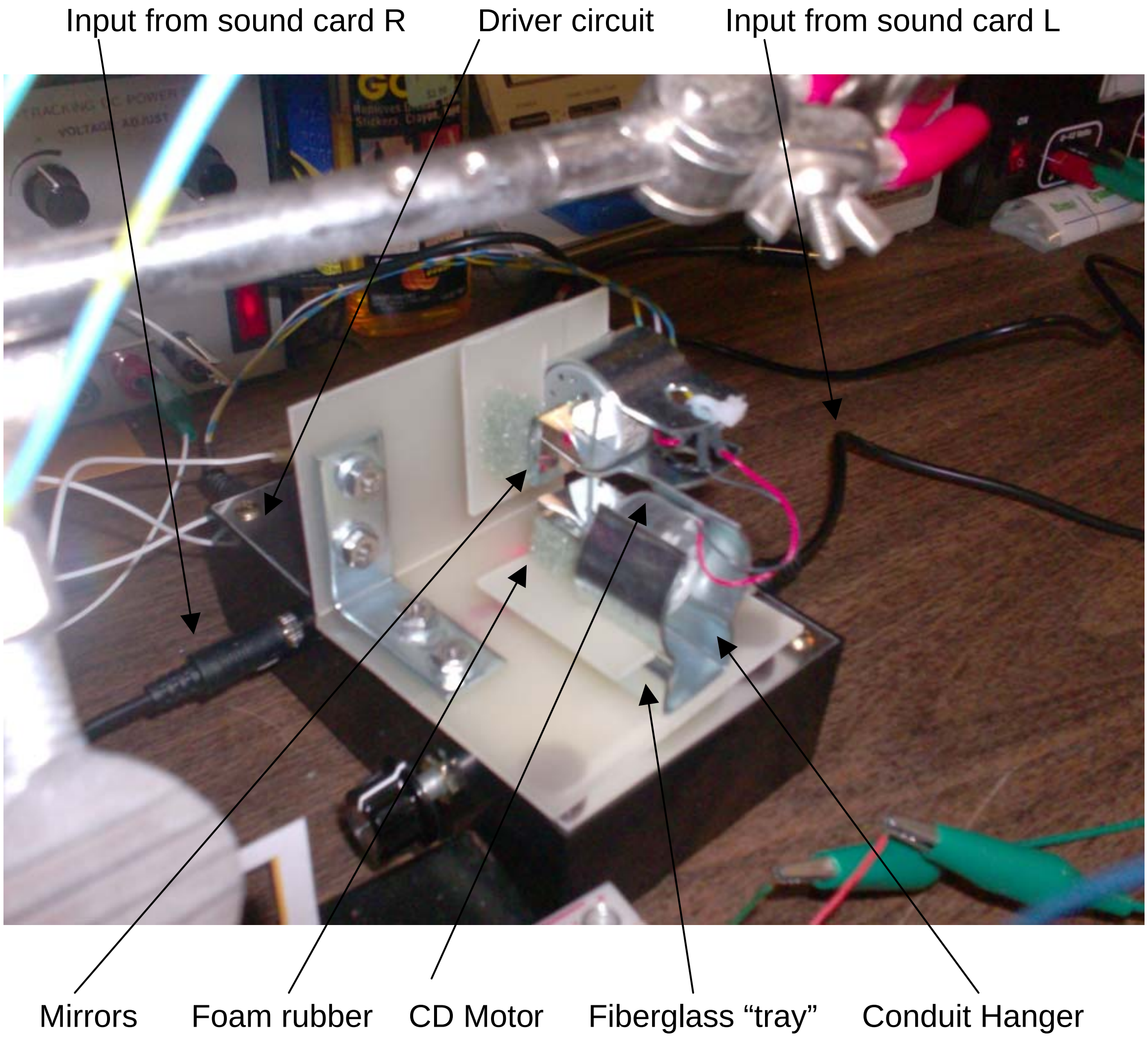
A short summary of how a homemade laser light show works: A 2-channel analog voltage signal, whether from an analog audio source or oscillators or computer Digital-to-Analog conversion (sound card) is applied to the inputs of 2 Drivers. The driver circuits increase the power of the waveforms so that low impedance (AC resistance) mirror galvanometers can be actuated. A mirror galvanometer, in simplest form, is like an ammeter with a mirror stuck onto its needle. Run current through it and the mirror twists around, returning to its original spot when power is removed. These can vary in price from cheap homemade, to thousands of dollar, high frequency units. Two drivers, driving two mirror "galvo's" are needed, mounted orthogonally (axes at 90 degrees) to create the X/Y scanning. The laser beams reflect off one mirror, then the other, then scatter on a wall or ceiling. When music is the audio source, all kinds of unusual, complex lightforms are created. When synthesized waveforms or oscillators are used, clean lightforms of the "Lissajous figure" type are created. These appear like spinning discs, spinning potato chips or pretzels, with a neat 3-D feel.

Audacity^R is great software to control a homemade laser light show, since it can do both, play 2-channel music, and generate 2 channels of synthesized waveforms, with effects! With Audacity, the setup becomes: 2 Audacity channels out to 2 drivers. 2 drivers actuate 2 mirror galvo's. One or several lasers reflect off the mirrors and to a wall or ceiling.

So, OK, you have a computer with Audacity, and a drawer full of laser pointers. What about the rest of the systems? Let us begin with the mirror galvos.

MIRROR GALVANOMETERS: These can be built or purchased. I found some nice, but low frequency units on Ebay, very low cost ($10 ea). But even lower cost is making your own! An ordinary low voltage (1.5-6VDC, reversible) DC motor can work very well; it should have easy shaft rotation (the permanent magnets shouldn't be very strong). I like the hockey-puck, disc-shaped motors found in junked CD ROM readers, the motor that actuates the tray opening/closing. Using 2-part epoxy, cement a steel washer onto the motor shaft, centered and parallel with the shaft. Next, cut 2 square pieces of first-surface mirror (reflective side on top of the glass) to approximately 15mm x 15mm.

This can be done with a glass cutter, just keep lots of Band-Aids handy. First surface mirror is available reasonably from American Science and Surplus; search on their website under “optics”. Using a contact cement like Pliobond, glue the mirror onto the washer. Next, get some ¾” steel conduit hangers from a hardware store…the motor just happens to fit nicely inside. Next, using unclad (no copper) fiberglass board (or other strong material), make a tray to fit underneath the mirror, around the notch in the conduit hanger, to hold a small cube shaped piece of foam rubber under the mirror, which will return the mirror to its original position and prevent rotation. Glue the tray into position, then glue the foam rubber to the tray, below the mirror (see pic below).



Note the orthogonal orientation of the motors/mirrors. Next, attach the conduit hangers with motors/mirrors to a 90 degree, L-shaped mount as shown. In this type of setup, the laser beams (note laser mounting clamp at top of pic) point down at the horizontal mirror at a 135 degree angle, reflect up to the vertical mirror, then reflect off to the ceiling at a 315 deg angle. A flat white ceiling gives best results. An alternative setup that I haven’t tried yet involves pointing the laser in horizontally, reflecting off the 2 mirrors mounted diagonally, with the beam exiting horizontally, but at a 90 deg angle from the input, to a wall.

DRIVER CIRCUITS: This circuit is very similar to the circuit published by Gordon McComb, in his book “The Laser Cookbook”, copyright 1988. This book is an excellent reference for the laser experimenter, but could use some updating with info on the newer diode lasers. I modified the circuit by adding a preamp before the driver to better match the output from a computer sound card headphone output. Note that there are two identical drivers, one for the left channel and one for right, driving the x and y axis mirror galvo’s.

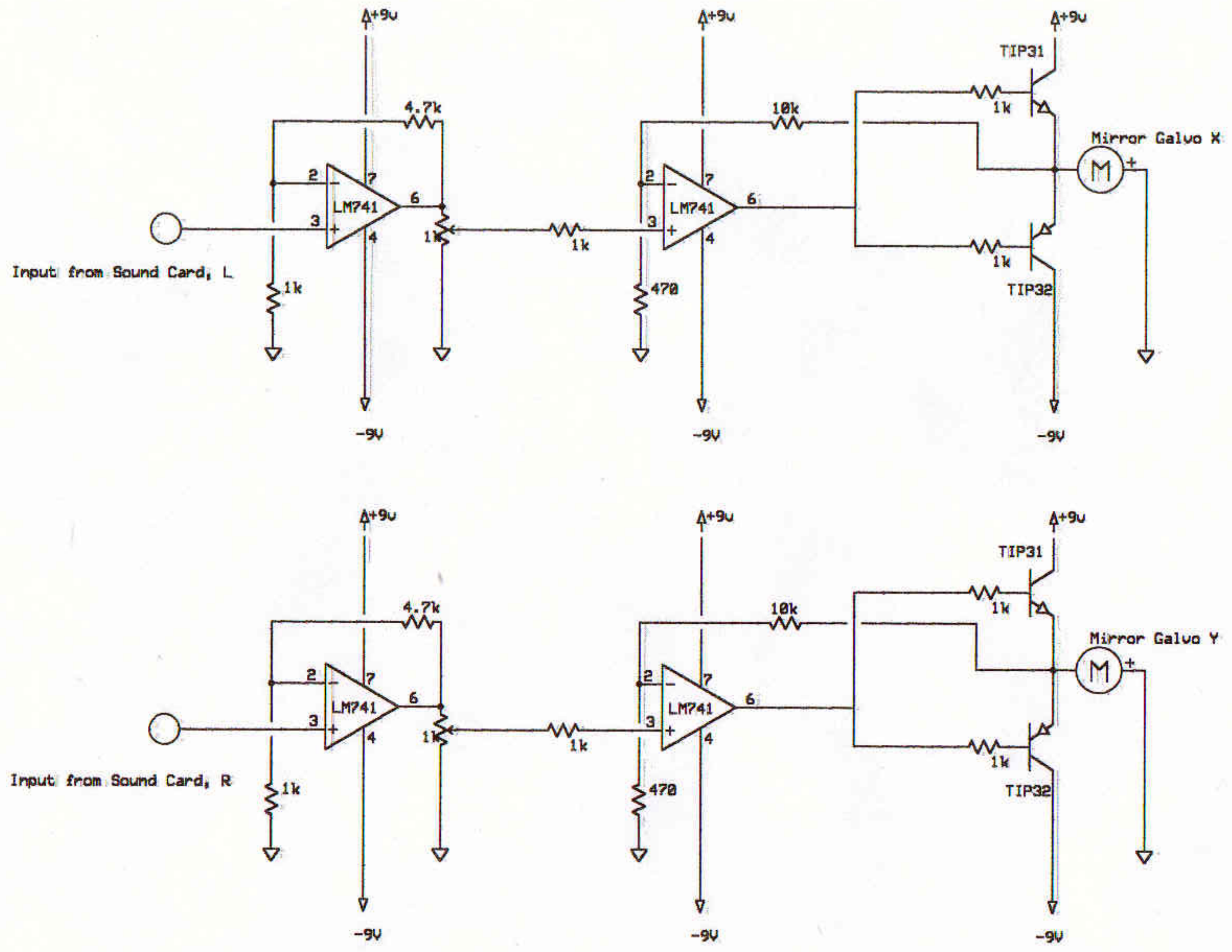
The first opamp, at far left, takes in the soundcard analog audio and amplifies the voltage approximately X5. The opamp output goes to a potentiometer, allowing adjustment of the amplitude into the driver. The second opamp, and the complementary pair of transistors (an NPN and a PNP, TIP31 and TIP32) form a push-pull type of amplifier, with crossover distortion low enough for good laser show effects. This push-pull or complementary pair amp works better than a capacitor-coupled amp such as an LM386 because it can continue to apply the positive or negative voltage to the galvo longer than through a capacitor; in other words it has better low frequency response, to match the response of the homemade galvo’s.

The circuit can be temporarily set up and used on a solderless breadboard, and when you’re happy with the performance, solder it together and enclose it. I placed the mirror galvo unit on top of the driver enclosure.
An easy input connector scheme is to use 2 x 3.5mm stereo jacks, one for left, one for right. Remember to wire them such that the jack tip forms one input and the jack ring forms the other input. From the computer sound card, connect a 3.5mm splitter (one male 3.5mm plug to 2 female 3.5mm jacks) to the soundcard headphone output, then use 2 male/male 3.5mm extensions, typically 6’ long, to connect to the driver inputs from the splitter.

For the motor (mirror galvo) outputs, this can be hard-wired, or use 2 mono 3.5mm jacks/plugs so that other mirror galvo units can be substituted/tested. I chose to use one 3.5mm jack/plug for simplicity. If using the 3-contact stereo plug, you need to form a single ground from two of the motor wires. Then tip and ring are wired to the x axis and y axis motors respectively.

Powering the driver: Note that a split (+ and – voltages) supply is required to swing the mirror galvos in opposite directions. This can be done easily with 2 x 9-V batteries, although new, small 9V batteries won’t be able to power the galvos for long. Better to use 2 x 9V battery packs made up of 6 AA batteries. Optimally, use a bench top split power supply that uses wall current. The parts (opamps, transistors, resistors, enclosure, jacks & plugs) are all available from All Electronics (allelectronics.com).

Following is the complete circuit diagram:



Nick Cinquino

Laser Show Mirror Galvo Driver

Audacity Controller	Rev 1.0 1/8/09	

C:\Program Files\ExpressPCB\Laser Galvo Driver.sch - Sheet1

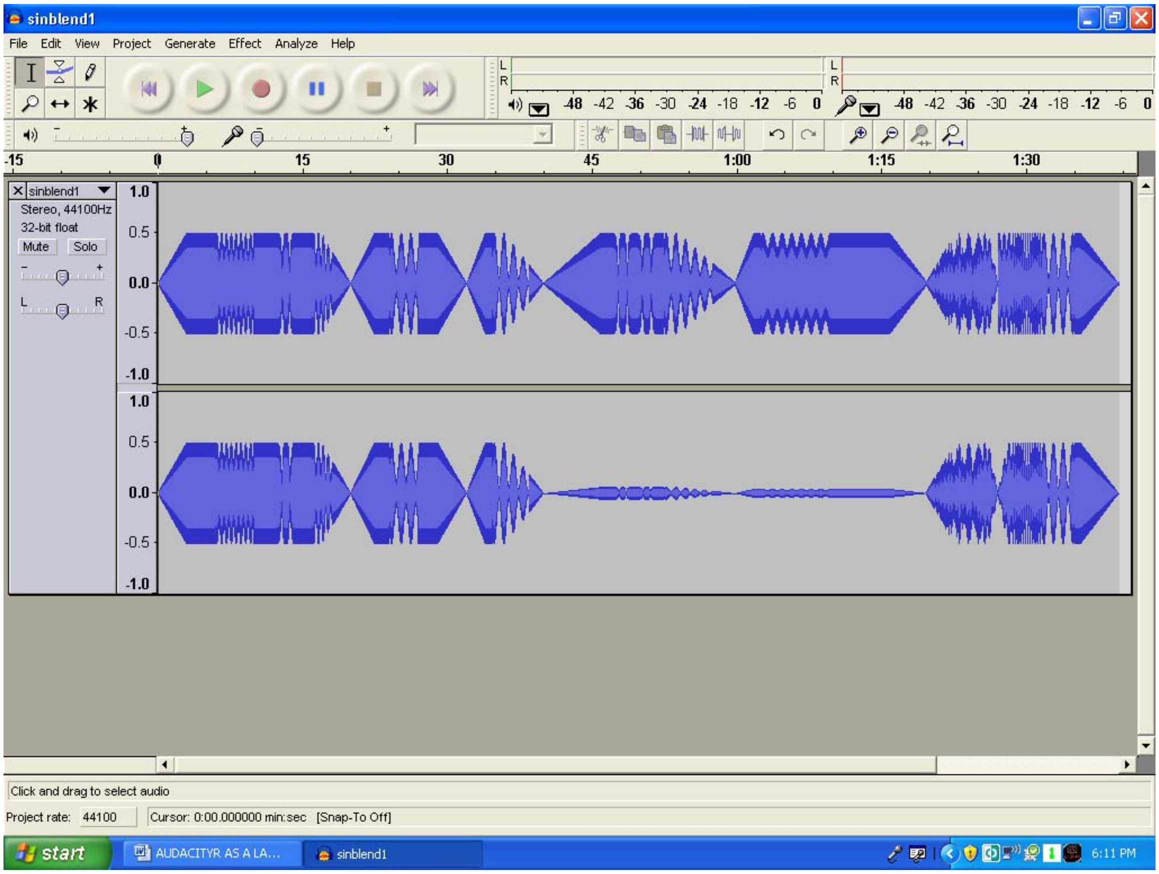
AUDACITY: Connect the computer soundcard to the driver, and make sure the mirror galvos are connected to the driver. Apply power to the drivers. You may see both mirrors “twitch” on powerup, then immediately return to center. If one or both mirrors slam over to one side, you may not be connected to the soundcard correctly, or the circuit has an error. Doublecheck your circuit and connections. As a quick initial test, set both driver pots to 50%, put a music CD into the computer, preferably something with lots of bass present, and play it with Windows Media Player. You should see some wiggling of the mirrors. If you saw some motion, the circuit is working well. Test complete!

To be able to hear music and output waveforms to the drivers/galvo’s, one additional splitter is needed: at the headphone jack, add another splitter. From the 1st splitter, run a cable to your external amplified speakers. At the second plug of the 1st splitter, add the other splitter, running these 2 cables into the driver jacks. Now, start Audacity and play a music file. Apply laser light to the mirrors, and adjust the driver pots and/or Audacity gain sliders as desired. Note how the lightforms respond best to deep bass notes, showing up often as complex spirals. Bass drum beats can create huge, irregular lightforms. Some music pieces actually contain some infrasound, below human hearing! The listener may sense it and feel “expansive” or have some other emotional reaction. Air Liquid and Jesse Cook seems to use infrasound often, and these show up in the lightforms as huge pulsing, rotating ellipses! Other bands having unusually interesting lightforms include Pink Floyd (surprised?), Moody Blues, Technotronics, Fleetwood Mac, and The Who.

Next up: synthesizing lightforms. First, some thoughts on frequency response…most sound cards can’t output very low frequencies, say below 10Hz, so consider that range unusable. Upper response is likely well past 5-10KHz. The drivers should be useable through the entire range of infrasound through ultrasound. The mirror galvos are very sensitive to the low frequency range, well below 10Hz, are still very sensitive up to 50Hz, start losing sensitivity up to 120Hz, and are pretty much insensitive past 200Hz. Therefore, synthesized waveforms should be kept within the bounds of about 10Hz to 120Hz, at least for starting out.

Creating Lissajous figures makes a great Audacity project. If 2 sinewaves are generated, both at say 50Hz, you’ll get a diagonal line…they’re in phase. But if you run them out of phase, by making the 2nd sine a slightly different frequency, say 50.5Hz, they’ll be passing slowly in and out of phase, creating a slowly spinning disk. The greater the frequency difference, the higher the “spin” rate.

If you leave one generator at 50Hz and set the other at 100.5Hz, now they’re slightly out of phase with a 2:1 frequency ratio. This creates slowly rotating, warped figure 8’s, or by adjusting amplitudes, a rotating potato chip, my favorite. Try different ratios of the 2 sinewave generators. 3:5 makes something resembling a pretzel. 3:1 looks like a wavy hoop or ring…imagine that rotating! Many other complex lightforms are possible.



Stereo, 44100Hz
32-bit float

Click and drag to select audio

Project rate: 44100 Cursor: 0:00.000000 min:sec [Snap-To Off]

Audacity screenshot of a short but complex laser show, with multiple frequency ratios (in the 10-120Hz range), and multiple effects like fade, tremolo and phaser. The low amplitude sections generate specifically sized lightforms.

Following is an example setup for making the spinning disk with effects: Open an Audacity window and select generate, tone. Set it to 50Hz, sine, reduce amplitude to 0.5, for 20 seconds. Select projects, New audio track. Select generate, tone, sine 50.5Hz, 20sec, amplitude 0.5. Set the top track to full left speaker slider, and the lower track to full right speaker slider. Highlight the first 5 seconds of both tracks and select effects, fade in. Highlight the last 5 seconds of both tracks and select effects, fade out. Highlight 5 seconds of both tracks in the middle and select effects, tremolo, 80% wet, 2Hz. Highlight both tracks and select Quick mix. Save the project. Run it with laser light on the mirrors…now you’ll have an idea of how much fun Audacity can be with a laser light show!
I’m presently making various tracks at different ratios and pasting them together into a complex preprogrammed show.

LASER INFO: Green laser pointers seem very bright at only 5mW power since the human eye is most sensitive to green light. These can be used as is for the laser show. I remove the laser module from the metal housing and wire it up to a bench top power supply, fixing the laser module in a clamp. Red pointers may not be bright enough for large sized lightforms. 100mW and higher red diodes can be scavenged from old CDROM burners (lots of work but fun) or purchased online through Ebay. These definitely are bright enough. The bare diode still needs optics (collimating lens) and heat sinking, which are both accomplished easily if you obtain pre-made housings such as the Aixis housing or equivalent.

Typical laser diode housing with lens.

Then you simply solder wires to the diode, press-fit it into the housing, and adjust the beam focus. Powering these diode lasers requires a current controlled supply, such as can be easily made using an LM317 regulator. There are many websites detailing the procedure of extracting a diode from a CDROM burner, and often when you order a diode, an example of an LM317 circuit will be included with wiring/pinout information. Today you can also get blue laser diodes, such as are found in Blu-Ray units.

DISCLAIMER: Caution must be used when using these higher powered laser diodes; they are NOT eye safe. They can damage your eyes if it were aimed directly at the eye for even a fraction of a second. Always make sure your laser show is pointing in a safe direction, where no one will get “scorched”. Print the following warning sign and attach it to your laser show hardware. The author is not responsible or liable for any damage or injuries caused by this equipment. For informational purposes only.

Enjoy the show!